Morphologic and Hemodynamic Changes after Stent Placement for Experimental Carotid Aneurysm

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Summary

Stent assisted coil embolization is useful in treating broad neck aneurysms, and there are many kinds of stents that can be applied in the cerebral artery, however their characteristics are not well known. We investigated and compared morphologic and hemodynamic changes before and after stent placement when several different kinds of stents were applied to experimental aneurysms.

Experimental aneurysms in eight pig carotid arteries were used. Stents were placed covering the aneurysm orifice. Five Cordis stents (coil stent), two GFXs (multilink stent), and one Multilink (tube stent) were used in this study. After coil placement, the arteries were perfused with 70% ethanol, the specimens were embedded in polyester plastic resin and thin slices were stained with hematoxylin-eosin. Blood flow in the aneurysm was measured using digital subtraction angiography.

The parent artery was stretched in multilink stent (GFX) cases, and was most markedly stretched by use of the tube stent (Multilink). Stent placement with any type of stent decreased intra-aneurysmal blood flow.

Introduction

The use of coil embolization for cerebral aneurysms has become widespread [4] and its effectiveness has been established; however, broad neck aneurysms are still difficult to embolize completely. Stent assisted coil embolization is developing in treating broad neck aneurysms [5], and there are many kinds of stents that can be applied in the cerebral artery, such as a coil stent, tube stent, and multilink stent. Although there are many kinds of stent, the morphological and hemodynamic characteristics are not well known when they are applied to cerebral aneurysms. Stent placement can change the shape of parent vessels. In addition, intra-aneurysmal blood flow can be changed by stent placement and thrombus formation in the aneurysm can be induced. The purpose of placing the stent over the orifice of aneurysms is not only neck plasty but also to reduce hemodynamic stress on the aneurysm. Accordingly, we investigated and compared the morphologic and hemodynamic characteristics of several different kinds of stents when they were applied over the orifice of experimental aneurysms.

Material and Methods

Experimental aneurysms in eight pig (fas scrota, 15-20 kg) carotid arteries were used (table 1). The method was explained in detail in a previous article [2]. Briefly, the pig carotid artery was exposed and a venous pouch of about 5 mm was sutured to an artificial hole in the artery under general anesthesia. The physical conditions were constant. Patency was confirmed by angiography. Stents were placed covering the aneurysm orifice. Cordis stent (coil stent) in five, GFX (multilink stent) in two, and Multilink (tube stent) in one were used for this study. Flow in the aneurysm was measured using digital subtraction angiography, as described in detail in our previous article [10]. Contrast medium was injected by the Seldinger method and the density curves were obtained using experimental digital subtraction angiography. The mean transit time of several regions of interest, i.e. parent artery and aneurysm, were compared before and after stent placement over the aneurym orifice. After 30 minutes of stent placement, the arteries were perfused with 70% ethanol, the specimens were embedded in polyester plastic resin and thin slices were stained with hemtoxylin-eosin.

The hemodynamic effects and morphologic characteristics when stents were applied over the orifice of experimental aneurysms were compared among the three kinds of stent.

Results

Morphologic aspects of the parent vessel after stent placement (figure 1). The shape of the parent artery was well maintained when the coil stent (Cordis stent) was used (figure 1A-E), and three of five aneurysms thrombosed naturally. The parent artery was stretched in two multilink stent (GFX) cases (figure 1F,G), and one thrombosed naturally. The parent artery was most markedly stretched by the use of the tube stent (Multilink) (figure 1H).

Hemodynamic changes after stent placement (figure 2, table 2). The vessels were perfused with 70% ethanol after 30 minutes of stent placement and removed. Five of eight aneurysms naturally thrombosed and even in the non thrombosed aneurysms, intra-aneurysmal flow was markedly reduced.

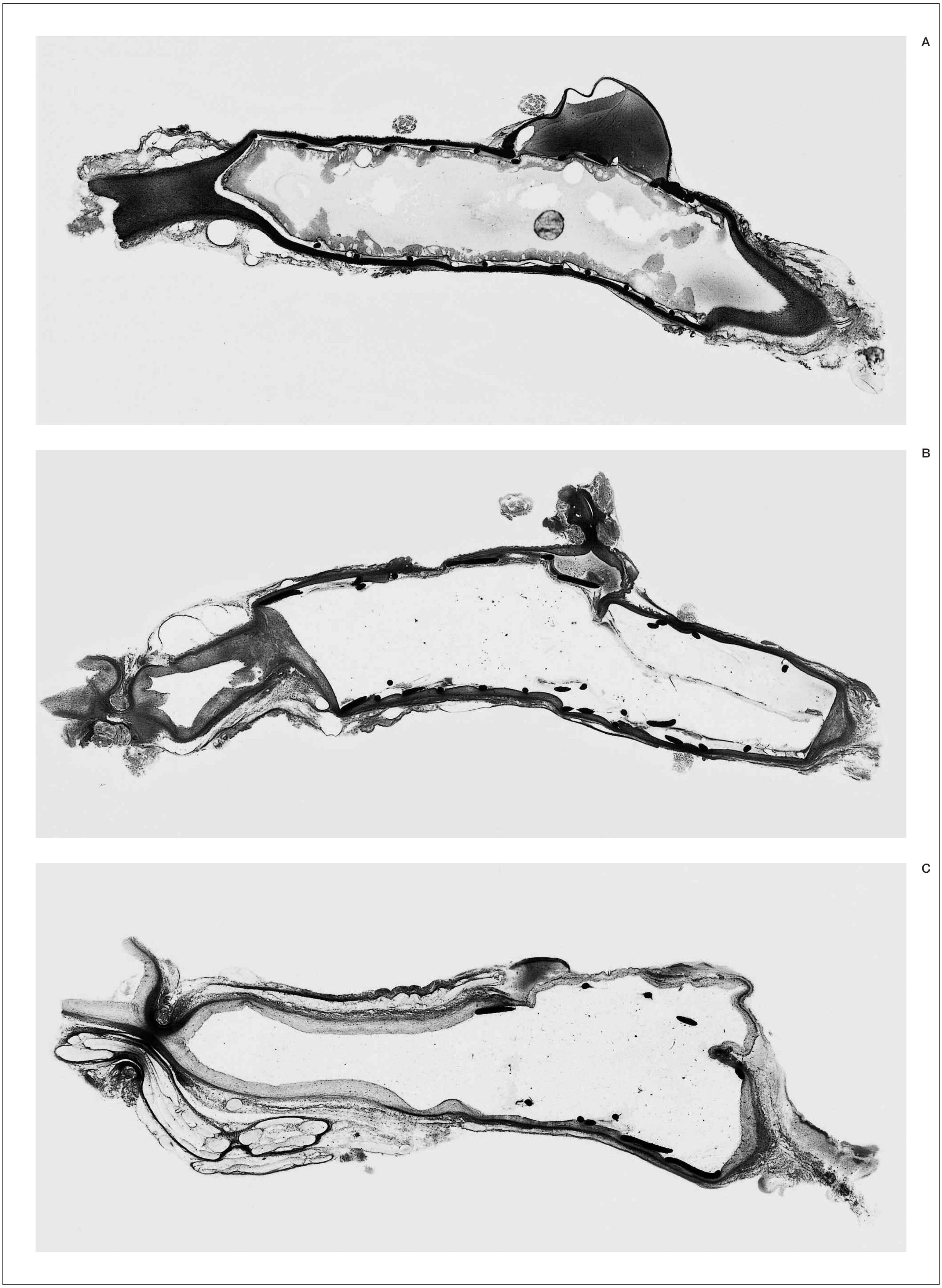
Discussion

The effectiveness of coil embolization for cerebral aneurysms has been established [4]; however, broad neck aneurysm is difficult to embolize completely [12]. Stent assisted coil embolization is useful in treating broad neck aneurysms [3,5,7,8,9] and there are many kinds of stents that can be applied in the cerebral artery, such as coil stent, tube stent, or multilink stent. However, it remains to be confirmed which is the most suitable in terms of shape and elasticity.

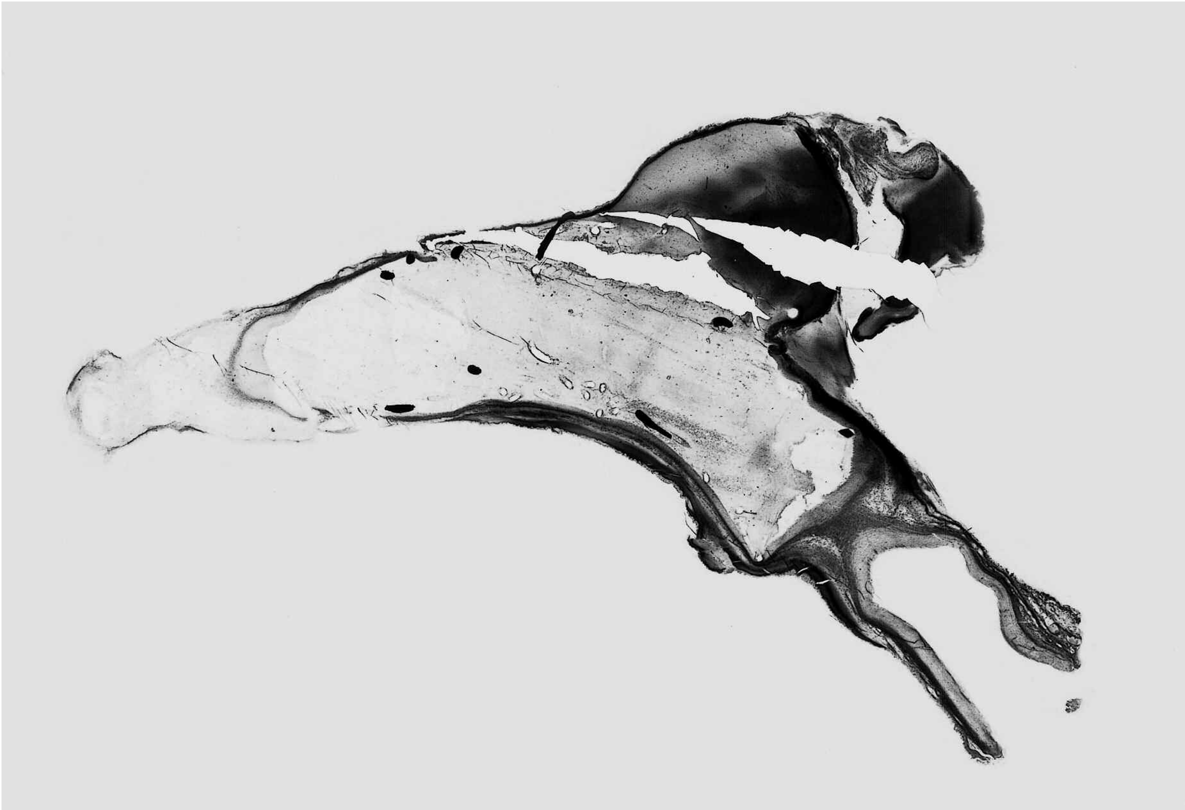
Higashida reported that the multilink stent (GFX) is useful in coil embolization, and good trackability has been established. In this study, the morphologic characteristics when stents were placed were investigated, and even the GFX distorted the parent vessel because the GFX was designed for application to stenotic lesions, and the radial force was too strong. The tube stent showed a stronger radial force than the GFX. The coil stent did not change the shape of parent vessels. As cerebral aneurysms rupture easily, changing the parent artery shape after stent placement is not desirable. From this viewpoint, the coil stent can be suitable for neck plasty of broad neck aneurysms since the radial force is not strong, and its elasticity is suitable for a vessel wall. All the stents currently available are for stenotic lesions, such

Table 1 **Summary of cases**

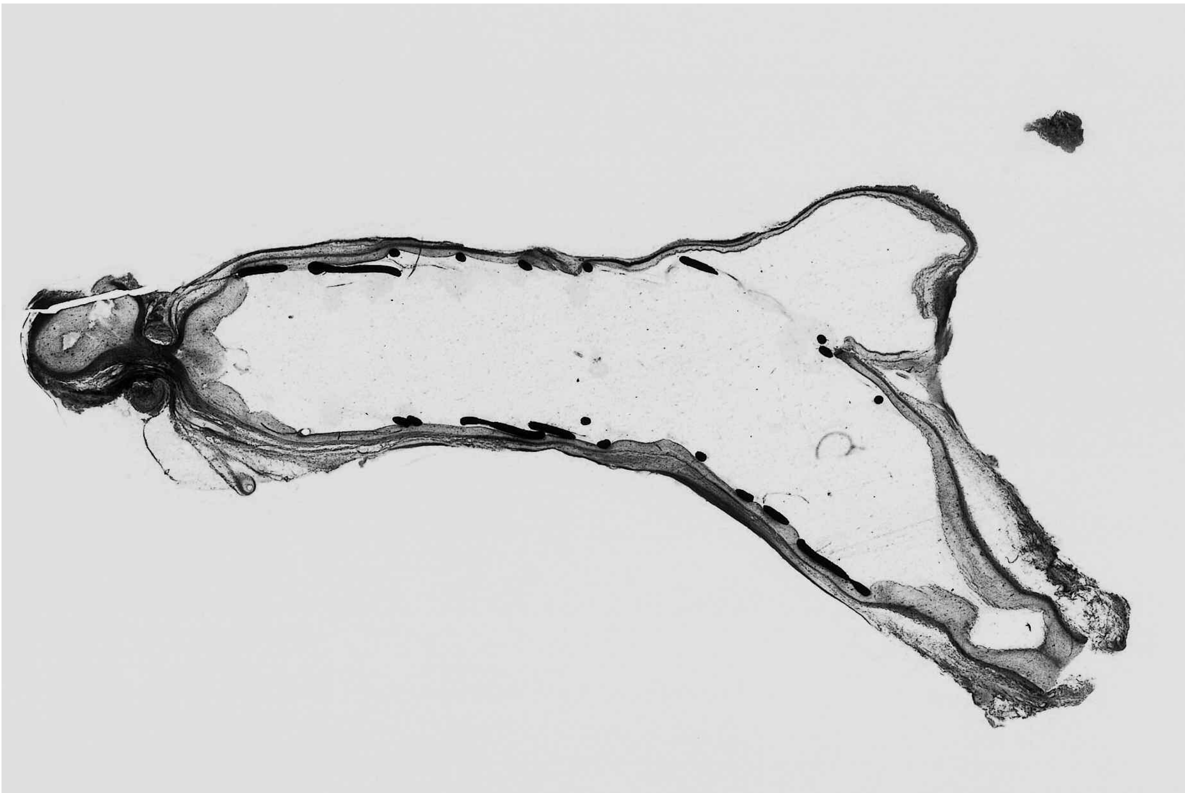
No	Stent	Size (mm)	Pressure (atm)	Histolgy	Figure
1	Cordis	4	5	thrombosed	1-A
2	Cordis	4	4	thrombosed	1-B
3	Cordis	3,5	5		1-C
4	Cordis	3,5	5	thrombosed	1-D
5	Cordis	3,5	6		1-E
6	GFX	3	4	thrombosed	1-F
7	GFX	3	6	thrombosed	1-G
8	Multilink	3	4		1-H


A
B
C

D



E



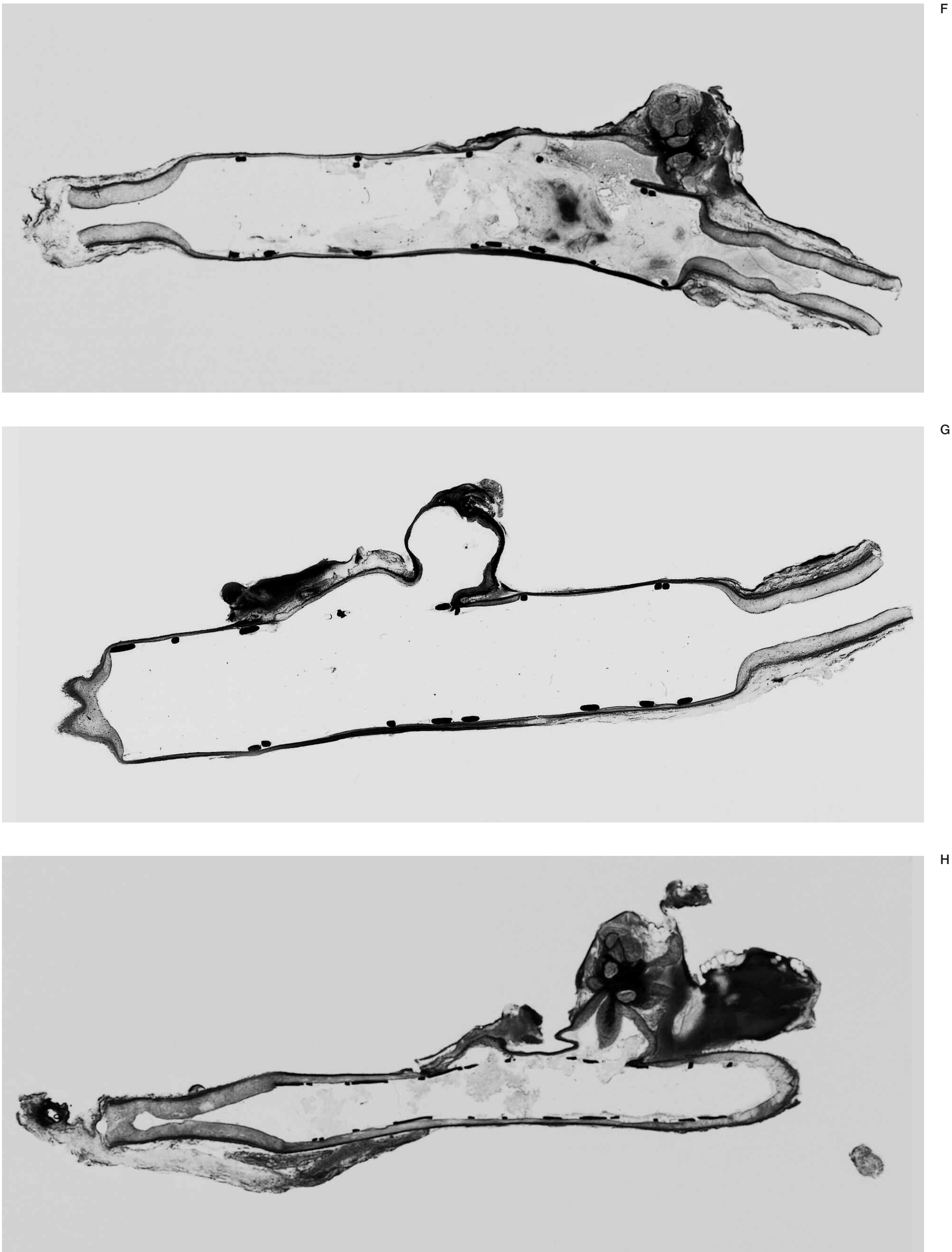


Figure 1 Photography of sections after stent placement. A-E) Cordis; F,G) GFX; H) Multilink.

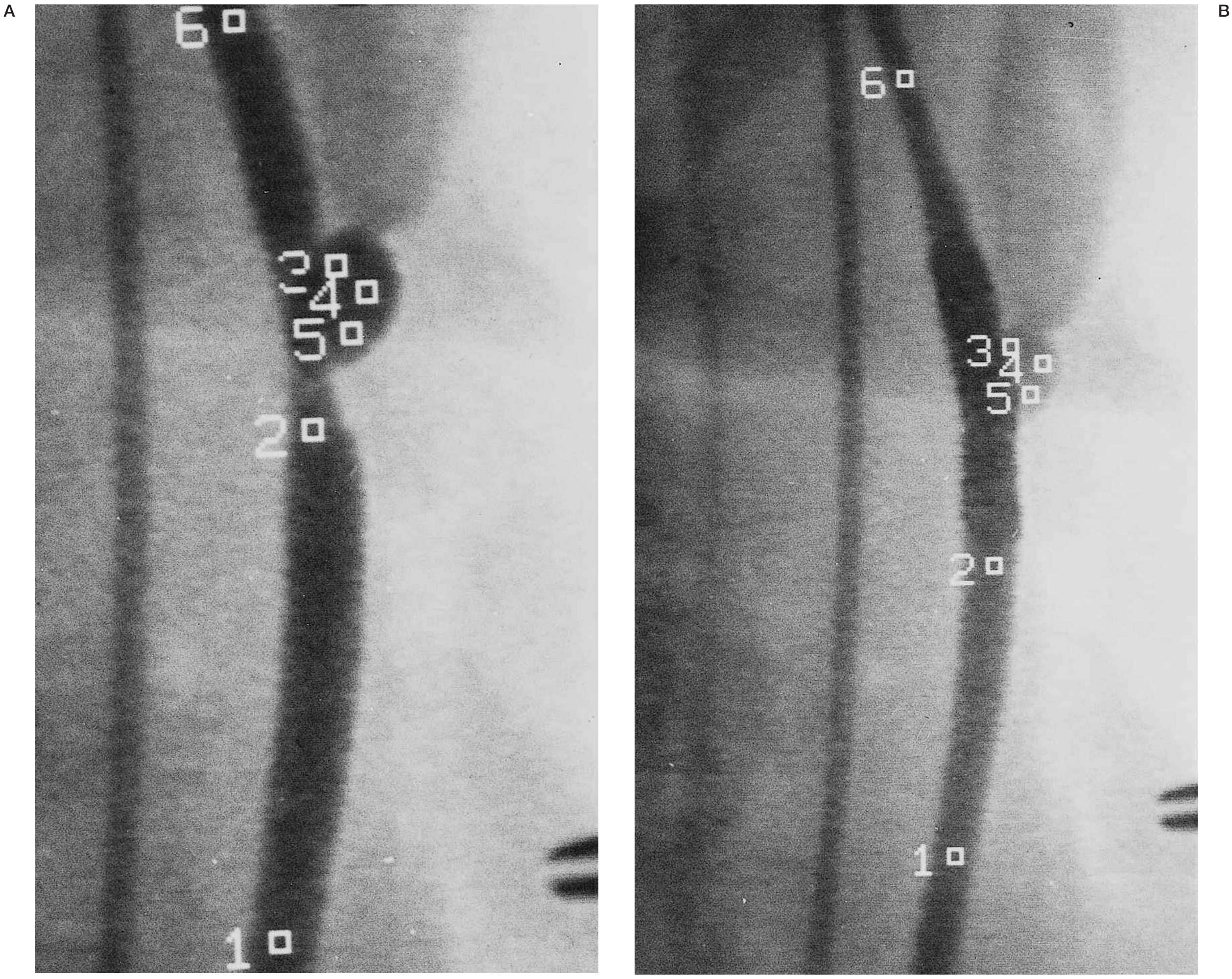


Figure 2 A) Left carotid angiography before stent placement. Small squares show regions of interest. B) Left carotid angiography after stent placemant.

Table 2 **Change of hemodynamics**

No	**MTT in aneurysm (sec)**		**MTT in parent artery (sec)**	
	before	after	before	after
1	1,11	2,68	1,28	0,88
2	0,45	2,83	0,54	0,45
3	1,64	2,39	1,17	1,29
4	1,44	n	1,36	2,23
5	0,93	5,16	0,68	1,04
6	0,78	n	0,72	n
7	n	n	n	n
8	0,86	1,43	0,49	1,24

MTT: mean transit time of dye, before: before stent placement, after: after stent placement, n: no measurement.

as coronary artery stenosis, and arteries in the extremities. We considered a softer stent is more suitable for cerebral aneurysms. It is important to develop stents for cerebral aneurysms for use in sophisticated endovascular surgery.

Stents decrease intra-aneurysmal blood flow [1,6,11] and in this study there was no marked difference between the stents. The use of a stent can markedly decrease inflow. However, as the experimental aneurysms in this study were side wall aneurysms, intra-aneurysmal blood flow after stent placement tends to easily decrease. Application of the stent over the orifice of experimental aneurysms is easier than in clinical aneurysms. In addition, the experiment was only small and more cases should be examined in the future.

Even so, a stent over the orifice of an aneurysm will decrease intra-aneurysmal blood flow. If an appropriate stent was designed, stents would become more effective. From this viewpoint, stent placement is a promising treatment.

Conclusions

Stent placement in experimental aneurysms was performed. Harder stents affected the shape of the parent artery, and we consider that a softer stent would be more useful in coil embolization. Stent placement with any type of stent decreased intra-aneurysmal blood flow.

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